VEGETABLES FOR THE HOT, HUMID TROPICS

Part 2. Okra, *Abelmoschus esculentus*

Science and Education Administration
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PREFACE

In the hot, humid Tropics, torrential rains during the monsoon season create special hazards for agriculture. Lands are muddied or flooded, entrance to plantings is restricted, weeds grow vigorously, chemicals applied are washed from the plants, and fertilizer is leached from the soil. High water tables drive oxygen from the soil, diseases thrive above and within the soil, and many plants are uneconomical to cultivate. These conditions make food production difficult, and agricultural skills imperative.

During tropical rainy seasons, the problem of producing highly nourishing food still exists. For the most part, the solution is to select appropriate species and varieties and know how to grow and utilize them in both conventional and unconventional ways.

Tropical diets are often unbalanced not only because of ignorance of sound dietary principles and because of food prejudices, but also because of a lack of good species and varieties. The Tropics are exceedingly varied in this respect, but knowledge is inadequate almost everywhere. Furthermore, even when appropriate varieties are known, it is often difficult to obtain seeds.

The purpose of this series of bulletins is to furnish information about vegetables that can be grown in the hot, humid Tropics. The vegetables covered are either not well known, at least with respect to some uses, or not well distributed, but are productive during tropical rainy seasons. The techniques recommended can be applied on a small scale or with a low level of technology. Seed sources are suggested when necessary.

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Part 2. Okra, *Abelmoschus esculentus*

By Franklin W. Martin and Ruth Ruberté[1]

INTRODUCTION

Because it is easy to cultivate and because of dependable yields, okra is one of the best vegetables for the Tropics. Although okra is suited to regions with moderate rainfall and is normally grown during the summer, it can withstand both heavy rain (fig. 1) and drought and can be planted at any time of the year for an edible crop. Okra bears early and can fruit over a long period. In many areas, it is resistant to diseases and insects and requires little care, but in other places it is plagued by viruses and other diseases, nematodes, and other pests. In some areas, it is considered to be a crop that guarantees results. Okra is also a crop of significant nutritional value. Okra merits more extensive use in the Tropics in the home garden, on the small farm, and at the large agricultural-enterprise level. In this publication, the value of okra for the hot, humid Tropics is emphasized.

Okra, *Abelmoschus esculentus* (L.) Moench or *Hibiscus esculentus* L., is called gumbo, gombo, or lady's finger in English-speaking countries, bhindi in India, and bamyah or bamiat in Arabic-speaking countries. The preferred generic name *Abel-*

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Figure 1.—A field of okra grown during the tropical rainy season at Mayagüez, P.R.

moschus is suggestive of the musky odor of the seed. The genus includes a few other species: *A. ficulneus* (L.) Wight et Arn.; *A. manihot* (L.) Medic., sunset hibiscus, used for its edible leaves; and *A. glutinotextile* Kagaava, a cross between *A. esculentus* and *A. manihot*.

The exact origin of okra is unknown. Its ancient use as a crop and its widespread distribution at an early date make tracing its origin difficult. DeCandolle (*6*)[2] reports that okra is mentioned in ancient sacred books of India. However, the presence of wild varieties in Ethiopia, in the region of the upper Nile river, and the presence of primitive perennial varieties in West Africa suggest an African origin. Probably, okra originated in Ethiopia or Eritrea and spread to the north and east as far as India and to West Africa. Slaves took the plant to the New World, where it was established before 1700. In West Africa, perennial forms are common. These forms are seldom seen in other parts of the world. The history and origin of okra needs to be clarified.

Okra is well distributed in both the Temperate Zone and the Tropics. It is especially important in northeast Brazil (*22*), in India, and in West Africa, and it is grown on a small scale almost everywhere. Dried okra is popular in Turkey, and oil from the seed is used in Greece. Okra has probably been bred more systemati-

[2] Italic numbers in parentheses refer to items in "Literature Cited" at the end of this publication.

cally in the southern United States than in any other region, but it has also been improved systematically in India and Brazil. In West Africa, improved varieties have been introduced from other countries.

FIGURE 2.—Variation in leaf lobing on a single plant.

BOTANY

Description and Varieties

Okra is generally a tropical annual plant. In Ghana, primitive perennial varieties with large, treelike trunks have been found (*30*). Okra is robust and erect and is variable in branching, and it has a deep taproot. Mature size varies from 0.5 to 4 meters. The stem is semiwoody, hispid in varying degrees, and sometimes colored by anthocyanin. Leaves are alternate, rarely entire, more often palmately five-lobed or five-parted (fig. 2). The degree of division increases with the age of the plant. Leaves are subtended by a narrow stipule.

The flower is axillary, solitary, hermaphroditic, regular, perfect, large, attractive, and conspicuous (fig. 3). The calyx consists of 8 to 10 separate sepals. The free petals are yellowish with large purple spots near the base. Numerous stamens are united in a tube

Figure 3.—Okra flowers.

around the style. The pistil consists of a five-lobed stigma, slender style, and a four- to six-carpelled ovary with axial, central placenta. Ovules average about 60. The fruit is colored white, green, or purple, grows rapidly, and matures into either a dehiscent, longitudinally-splitting capsule or an indehiscent capsule, sometimes recurved like a horn. The seeds average about 15 to 20 per gram. They are spherical, smooth, and dark green to brown in color. On germination, the seedling develops two almost circular cotyledons.

The pod is the principal portion eaten (fig. 4). It can vary in length from a few centimeters to 70 centimeters or more, in width from 1 to 4 centimeters. Color depends on the amounts of green and red pigmentation. Reddish or purple-podded varieties occur. A few varieties bear pods that are almost white. The cross section may be angular or circular, and the number of angles (sutures of the pod) varies from four to nine. One type of pod is circular in cross section (fig. 5). The axis of the pod can be perfectly straight or curved, but curved pods are often associated with poor pollination or insect damage. The pod and other plant parts can be

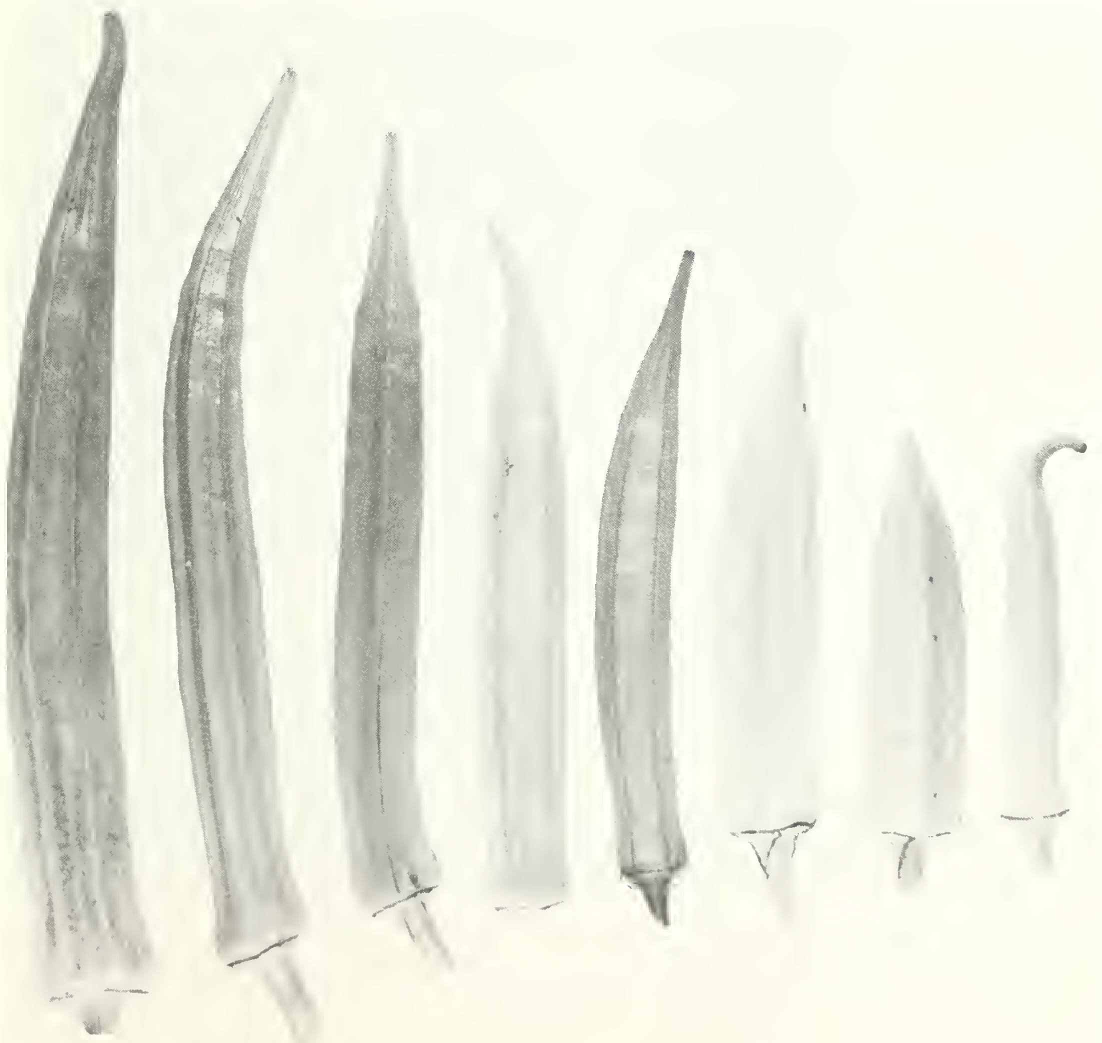

FIGURE 4.—Okra pods.

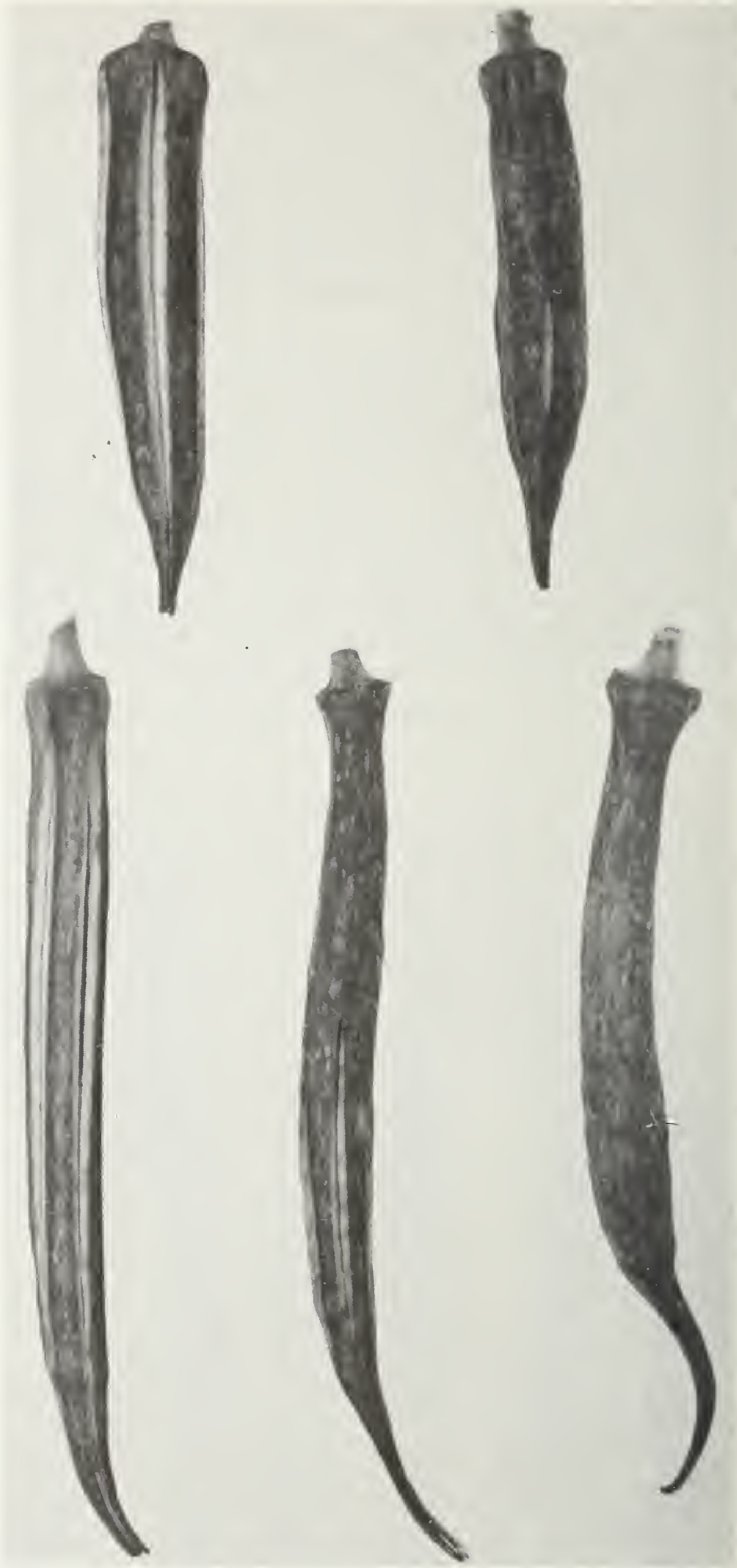

FIGURE 5.—Okra pods of various degrees of angling.

TABLE 1.—*Okra varieties seen in the Tropics*

Variety	Some characteristics
'Campinas' (1 and 2)	Early, productive, drought resistant.
'Chifre-de-Veado'[1] (several varieties)	Large, much branched.
'Clemson Spineless'	Dependable, high yields.
'Dwarf Green'	An old, traditional variety.
'Dwarf Green Long Pod'	A variety for fall, compact.
'Dwarf Prolific'	Small stature.
'Emerald'	Dark green, smooth, spineless pods, high yields.
'Gold Coast'	Dwarf, heat tolerant, long bearing, short pods.
'Green Velvet'	Early, high yields, smooth pods.
'Long Horn'[1]	Long, sutureless pods.
'Louisiana Market'	Short pods.
'Native Brown'	Purple stems and leaf margins.
'Perkin's Mammoth'	Long pod.
'Pusa Sawani'	Resistant to yellow vein mosaic.
'Sabour Selection'	Branching tendency.
'St. John Bush'[1]	Enormous size, long life.
'White Velvet'	White fruits.

[1] Varieties recommended for continuous production during the year.

glabrous or spiny. The small spines of mature fruits irritate the skin.

Varieties differ with respect to physiological characteristics such as response to season, adaptability, and resistance to drought, rain, and insects and diseases. These differences are not well documented, and study is needed to describe varietal characteristics. Okra requires warm temperatures for its maximum development. Under warm conditions and long days, okra flowers and fruits with exceptional vigor. Old plants of some varieties continue to bear during the season of short day lengths. Plants from winter plantings flower and fruit at an early age when plants are still small, and their yields are low. Growth is also restricted in cool climates.

Okra is not well known in all of its forms throughout its range. With some exceptions, the best known varieties in the Tropics come from a few types bred or developed in the Temperate Zone. Although these varieties may be suited for some regions, they are not well adapted to all areas, and in particular they are not adapted to the tropical winter. On the other hand, a few unnamed varieties of the Tropics might fill special needs not met by the temperate varieties. Some varieties seen by the authors are given in table 1.

Characteristics usually sought are a high yield, uniformity, long and continuous production, spinelessness, the pod type preferred

locally, a low fiber content, and good keeping quality. Such characteristics as nematode and drought resistance are also important. Little attention has been given to breeding better varieties for the hot, humid Tropics, and indeed almost none has been given to the needs of the home gardener, who is more interested in continuous rather than concentrated production.

In the Tropics, there are varieties that resist the rainy season and yield over a long period. 'Clemson Spineless' and 'Emerald' are excellent for the Tropics. The varieties recommended for continuous production during the year are noted in table 1. Perennial Ghanian varieties (fig. 6), now not available elsewhere, may be the best types for long life and minimum care.

Floral Biology, Genetics, and Breeding Potential

In one of the best studies made of the floral biology of okra, Sulikiri and Rao (*31*) carefully observed six varieties and concluded: flower buds were initiated 22 to 26 days and first flowers opened from 41 to 48 days after sowing. Once initiated, flowering continued for 40 to 60 days (varieties that bloom late continue to flower over a longer period). Green fruits of appropriate size and tenderness were produced from the flower in 6 to 8 days.

FIGURE 6.—Large plant of the late-flowering type with a tendency towards perennial behavior.

The majority of okra flowers open early, before sunrise, but a small percentage open in the early hours of the morning. Anthers dehisce, and automatic self-pollination may occur at anthesis. Bees are active in cross-pollination. All events are essentially over by midmorning.

Most okra flowers produce fruit. When artificial pollination was used, 80 to 100 percent success was recorded in stimulating fruit set. However, pollen stored for 1 day at room temperature was not able to stimulate fruit set. The stigmas are most receptive to pollinization at anthesis, but surprisingly they are quite receptive to artificial pollination 1 day before anthesis. Some stigmas can be pollinated successfully 1 day after anthesis.

Self-pollination is done by tying the flower bud closed the day before anthesis. Controlled pollination can be achieved by emasculating buds the afternoon before anthesis is expected. Because pollen is not then available, the best time for self- or cross-pollination is the following morning. Pollinated flowers must be covered to prevent further pollination by insects.

Under field conditions, cross-pollination in okra is high. Honey bees and several kinds of wild bees are commonly observed visiting flowers. Mitidieri and Vencovsky (*23*) estimated that cross-pollination is as high as 42.2 percent, but others have reported cross-pollination rates of 4 to 32 percent. Because the flowers easily pollinate themselves, a high rate of cross-pollination by visiting insects is probably unusual. Common varieties are probably always somewhat heterozygous in spite of observed uniformity.

The chromosome number of okra is high, 130 (*15*). Other species of the genus have 36 or 58 chromosomes. *Abelmoschus esculentus* seems to be an allopolyploid, a conclusion reached from observations of its hybrids with other species.

Erickson and Couto (*8*) report that four characteristics—petal blotch, heavy stem pigmentation, petiole pigmentation, and early bearing habit—are all simply inherited. Other investigators have found examples of simply inherited characteristics including degree of leaf lobing, calyx color, petal base color, and petal venation color (*16*). The evidence suggests an alloploid origin of okra from simple species. Thus, in spite of a high chromosome number, the species is acting as a diploid.

On the other hand, quantitative characteristics—plant height, yellow-vein-mosaic infection, days to flowering, yields per plant, and seed weight—have high heritabilities and high advances expected under selection (*26*). Rao and Ramus (*28*) have shown that the yield of okra varieties is influenced chiefly by the number of pods per plant. But in an extensive analysis of 30 varieties, Singh et al. (*29*) found that yield is related to fruit weight and the number of fruits per plant. In that study, high heritabilities were

measured for fruit diameter, fiber content, fruit length, and vitamin-C content. Okra responds well to breeding efforts and is easy to manage.

Self-pollination apparently does not significantly reduce vigor (*11*), and with selection for type, may increase yield. The search for heterosis has not been fruitful. F_1 hybrids are usually intermediate to the parent varieties with respect to principal characteristics (*32*). Nevertheless, heterosis has been reported (*2*, *13*). Observations of the superiority of the F_1 hybrid over the mean or the most superior of the parents, however, do not reveal a typical form of heterosis comparable to that in maize. The behavior of okra hybrids is typical of crops that are normally self-pollinated.

Mutations for plant height have been induced in okra by gamma rays and chemical agents (*33*). Gamma-ray treatment of seeds increased time to germination and increased variation for plant height, for days to flowering, and for yield (*24*). X-rays have induced variations in height, number of pods per plant, number of seeds per pod, and number of nodes and of branches (*19*).

Hybrids of okra with other species have been obtained. The most effective technique is by means of ovule and embryo culture (*10*). Viable hybrids were obtained of *A. esculentus* with *A. moschatus* and *A. ficulneus,* as well as with the combination of *A. tuberculatus* and *A. moschatus.* The cross of *A. tuberculatus* with *A. manihot* has been successful even without embryo culture (*20*).

CULTIVATION

Climate and Soil Requirements

Although the climatic requirements of okra are well known, little has been recorded of varietal differences in response to the principal limiting factors. Okra is a warm-season crop. It prospers in the hot, dry Tropics and in the hot, humid Tropics, but it is out of place and unproductive in cool highlands. High temperatures are necessary for seed germination and growth. In a study in India (*4*), high temperatures were correlated with large plant size, large fruit size, and high production of flowers and of fruit.

Okra growth is also influenced by day length (*4*). Short day lengths stimulate early flowering and reduce vegetative growth. In a study of 265 varieties during the dry season in Puerto Rico, when day lengths are about 11 hours, all varieties began to flower at an extremely early stage and did not achieve heights normally characteristic of summer plantings. Nine varieties were tested more carefully in Brazil (*27*) under closely controlled day lengths: seven were day-length sensitive and can be classified as short-day

plants. In this experiment, 'Clemson Spineless' was almost unresponsive to day length, perhaps accounting in part for its wide adaptability. Okra plants flower but tend to abort buds when day lengths are long.

The ideal time to plant okra in the Tropics is much the same as in the Temperate Zone: somewhat after March. In many parts of the Tropics, this time corresponds to the beginning of the rainy season. Several plantings can be made at 4- to 6-week intervals. Okra, however, can be planted at any time of the year in the Tropics, and an edible harvest can be expected.

When the rainy season occurs during the time of short days, or when a winter crop is desired, it is best to plant the winter crop early in the year, no later than September. The plants will develop fully before day lengths begin to inhibit vegetative growth. Some of the large, vigorous, much-branched varieties, such as 'St. John', a variety of the Caribbean, are suitable for this purpose. These types are probably related to the perennial varieties of West Africa (fig. 6).

Okra is said to be only slightly tolerant of acidic soils, but its wide distribution in the Tropics and its vigorous growth wherever sufficient fertility exists contradicts this general observation. Okra tolerates a wide range of soil conditions. It is susceptible to nematodes frequently found in sandy soils, and it is intolerant of poor drainage, which leads to root diseases. On the other hand, as a vigorous and rapidly growing annual, okra responds to a high level of nutrients in the soil. On a small scale, an appropriate level of nutrients can be provided by adding manure or other organic material to the soil. The soil can be formed into beds if flooding is likely. The planting area should be well prepared by plowing and disking, or by spading or rototilling.

Spacing and Seeding

Because it grows vigorously, okra needs a fully sunny location. Rows can be spaced from 30 to 100 centimeters apart, and plants in the rows from 10 to 60 centimeters (3). Dwarf varieties are usually planted closer together. There are 15 to 20 seeds per gram, or about 4 to 8 kilograms of seed needed per hectare. It is usual to plant two to three times the number of seed required. Under good conditions, a germination rate of 50 percent is acceptable. For maximum yields per plant, the plants are thinned after germination. Seeds are planted about 2 centimeters deep. Okra seeds are sometimes treated for a half hour with acetone or alcohol, or for 24 hours with water to improve germination. Treatment of the seeds for 1.5 hours at 45° C seems to stimulate germination (25). Seeds germinate poorly at ground temperatures of 20° C or less.

Optimum temperature is 30° C or more. The problem of seed germination is complex and has not been completely resolved.

Because of irregular germination, seeds must be maintained moist until they establish themselves. Hard crusts of the soil following rain or irrigation need to be broken up. Seeds germinate in 4 to 14 days. The newly germinated plants need about a week or more before they begin to grow vigorously.

Planting Care and Weed Control

Okra is a fast-growing crop that needs much care in order to reach its full yield potential. However, it is also a crop that almost always bears at least something of a crop, even when neglected. Some cultural practices often recommended are summarized in table 2. From 200 to 400 kilograms of a mineral fertilizer (10–20–10) per hectare, for example, might be desired before planting, with 35 to 50 kilograms of a high N fertilizer per hectare used later as a side dressing to keep plants growing vigorously during fruit production.

If germination has been good, it might be necessary to thin out some plants. Thinning should be done cautiously to avoid reduction in yields. Spacing will depend on the variety. Whereas an American variety such as 'Clemson Spineless' might require only 0.2 square meter for satisfactory yields, the large African plants may each need 1 square meter of space.

Weed control is important in okra production, especially when

TABLE 2.—*Some cultural practices recommended for okra*

Cultural practice	Treatment	Time of application	Note
Fertilization	Incorporation of compost or organic material in soil.	Before planting	Seldom gives optimum growth.
Do	Complete mineral fertilizer, 400 kg/ha.	At planting	Varies with soil fertility.
Do	Nitrogen fertilizer side dressing, 50 kg/ha.	3 months after planting.	Extends harvest.
Spacing plants	Thin as desired	3–6 weeks after planting.	Before plants reac' 30 cm.
Weed control	Shallow hoeing	Early, while weeds are small.	Costly.
Do	Selective hand weeding	As plants mature	Avoid climbing vines.
Do	Polyethylene mulch	Before planting	Reduces water requirement.
Irrigation	Overhead sprinkling	Variable; avoid wilting.	Preferred.
Do	Furrow irrigation	Variable	Adequate.

the plants are small. Weed control by hoeing is useful. In a well-fertilized planting under optimum soil-moisture conditions, okra should rapidly shade out weeds after one to three hand weedings. Weeding by hand or machine should be shallow to avoid damage to the roots.

Irrigation will depend on facilities available. As a general rule, okra prefers moist soil for rapid growth. Plants should never be allowed to wilt, but flooding should also be avoided.

Flowering, Fruiting, and Harvest

Okra production begins early and continues over a long period. Flowering begins from 35 to 40 days after sowing of seed. Flowers remain open for only 1 day, and the pods develop rapidly thereafter (fig. 7). The young fruit can be harvested at any stage until the fiber content becomes excessive. As a general rule, fruits are ready for harvest 4 to 10 days after flowering.

Because of the rapid growth of okra fruits, plants should be harvested at least every other day. In climates where growth is especially vigorous, it may be necessary to harvest every day. The evening is the best time for harvest, for the highest quality fruits

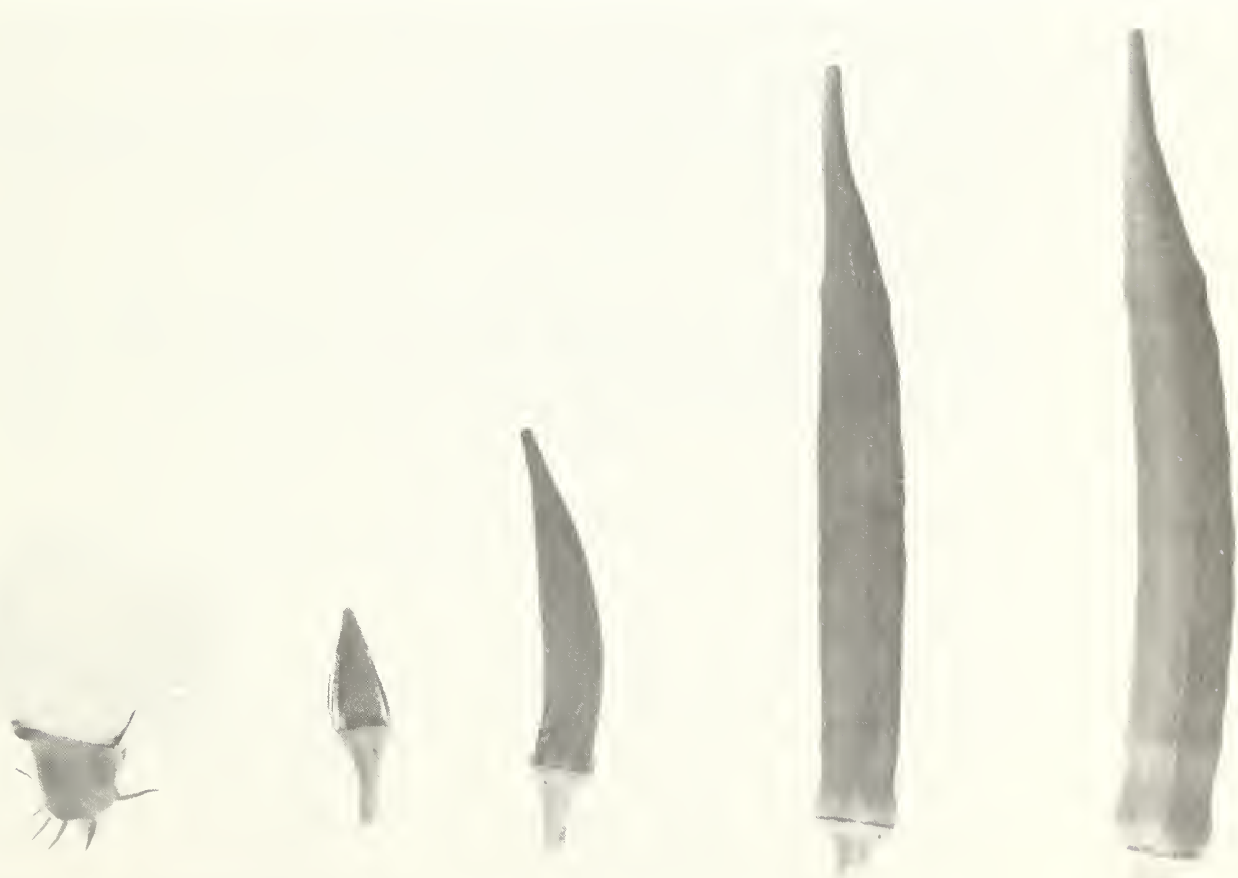

FIGURE 7.—Growth pattern of okra pods, from left to right 0, 1, 2, 5, and 7 days.

are obtained then. All large pods are removed at harvest by means of a sharp knife or pruning shears; with some varieties the fruit can be snapped off. The fruits are immediately removed from the sun, for their quality decreases rapidly after harvest. It is usually possible to distinguish by eye the overmature fruits, but if in doubt a slight cut can be made in the fruit just above the calyx remnants. If fibers are encountered, the fruit is too mature for conventional use. About 5 weeks are required from flowering to the production of dried pods with fully viable seeds.

Okra fruits are best used fresh. It is undesirable to hold them for long periods, but they can be held for several days in a household refrigerator. Pods stored at 7° to 10° C at a humidity of 85 to 90 percent have retained adequate quality for 7 to 10 days. After being cut and blanched, the pods can be frozen for long storage (1 year or less).

The okra plant continues to flower and to fruit for an indefinite time, depending on the variety, the season, and soil moisture and fertility. Regular harvesting stimulates continued fruiting. When pods are not removed, the plants age rapidly. Signs of aging are a reduction in the production of leaves and an increase in the depth of lobing.

Some okra varieties are less sensitive than others to harvesting. The heavily branching varieties can mature a crop of seed while new fruiting suckers develop. For the home garden, such varieties afford special advantages, particularly heavy and prolonged yield associated with minimum input.

The pods, when harvested for seed, should be dried in the sun for several days. Twisting the pods in both directions usually breaks loose the segments of the capsule and releases the seed. Seed can be stored under cool, dry conditions for about 2 years.

Some typical okra yields are given in table 3. However, adequate data are not available on okra production in the hot, humid Tropics, especially at the level of the home garden or subsistence

TABLE 3.—*Typical yields of okra pods and seeds*

Crop	Variety	Place	Yield (tons/ha)
Green pod	'Clemson Spineless'	U.S.A., intensive cultivation	17.7
Do	'Emerald'	Virgin Islands	12.0
Do	'Pusa Sawani'	India	5.3
Do	'Campinas 1'	Brazil	5.7
Do	'ITO 29'	Nigeria	7.8
Seeds		U.S.A.	2.4
Do		Brazil	2.1

TABLE 4.—*Principal diseases and insect pests of okra*

Disease or insect	Damage	Control[1]
Diseases:		
Fusarium wilt	Sudden wilt of branches	Rotation.
Oidium leaf spots	Irregular spots	
Pod spot	Value of pod destroyed	Rotation, resistant varieties.
Sclerotium blight		Use new land and rotation; destroy plant refuse.
Verticillium wilt	Dieback	Rotation helps.
Viruses, especially yellow vein mosaic.	Reduced vigor and production	Use resistant varieties; eliminate diseased plants; reduce insect vectors.
Insects or nematodes:		
Corn earworm	Holes in pods	Remove and destroy deformed pods.
Cotton aphid	Reduction in vigor, curled leaves.	Release purchased lady beetles.
Leaf beetles, flea beetle	Holes in leaves	Use most tolerant varieties available.
Leafhoppers	Stunted leaves	Destroy crop residue and rotate crops.
Pink bollworm	Pods infested	Destroy infested material and replant elsewhere.
Root knot nematode	Root lesions, reduced vigor	Avoid infested soils; grow a nematode-resistant crop before okra is planted.
Stink bugs	Pods punctured and deformed	Remove and destroy deformed pods.

[1] Chemical-control measures are not given because of variations in laws governing the use of pesticides. Local authorities should be consulted for information on chemical-control techniques and on current, local laws affecting the use of pesticides and other chemical controls.

farm. The data do not emphasize fully that okra is one of the most dependable sources of food over a relatively long period in the hot, humid Tropics, and at least in the season of long day lengths, one of the best plants for the hot, humid Tropics.

PESTS AND DISEASES

Okra is sometimes said to be relatively free of pests and diseases. This is often true in small, isolated plantings, but when okra is grown on a commercial scale, the opportunities for pest and disease attack are multiplied. A wide variety of pests and diseases of okra have been reported, and it would be beyond the scope of this bulletin to review them all. Furthermore, because pests and diseases vary in different parts of the Tropics, and because the regulations for use of pesticides vary, it is difficult here to recom-

mend chemical-control measures. For India, chemical controls have been evaluated (*18*).

In some parts of the Tropics, the yellow vein mosaic is a serious problem. When this disease is present, the resistant Indian variety 'Pusa Sawani' can be used. In the Caribbean, the native varieties, including 'St. John', have not shown mosaic.

Damping off of seedlings associated with *Fusarium, Pythium,* and perhaps other organisms is generally found when the soil is excessively wet. Residues of rotting plants in the soil serve as sources of infection. Planting at the right time of year is a useful control measure.

In wet weather, fruits can be attacked by such fungi as *Choanephora, Rhizoctonia, Fusarium,* and *Phytophthora.* These diseases are hard to control, but measures to dry the plantings after a rain are useful. Shade or dense plantings may increase the likelihood of some diseases.

Insect infestations vary widely, but perhaps the most severe pest is the cotton aphid. By sheer numbers this species can kill the plant. The principal insect pests and diseases of okra are summarized in table 4. Controls for these conditions are not given because of the variations in laws that govern the use of pesticides from country to country. Local advice should be sought from the responsible authorities concerning local pests and diseases, local controls, and local laws affecting the use of pesticides and other chemical-control measures.

UTILIZATION AND NUTRITIONAL VALUE

Uses

Okra is used chiefly as a fresh vegetable. The pods are boiled whole or are sliced crosswise or diagonally before cooking, and the slices are then boiled or fried. Cooked okra is mucilaginous and is not always appreciated when first tried. Most people, however, rapidly acquire a liking for this vegetable. Frying reduces the mucilage and makes the okra acceptable. The slices can be treated with corn meal or flour before frying.

Okra slices are also used in soups, either as the principal vegetable or with other vegetables and meats. The famous gumbo soups of Louisiana depend on okra. The young seeds can be removed from the pods to make a dish not unlike green peas. Mature seeds have a harsh flavor.

Green okra pods can be sun dried to preserve them for the offseason. Young pods are used or the okra is first sliced to facilitate drying. Special varieties are sometimes used for this purpose, and

in Turkey okra is grown especially for drying. Green okra fruits are often canned, and sometimes they are preserved by pickling.

When the pods have become too fibrous for consumption as a green vegetable, they can still be cooked and the seeds then be pressed out of the pod. The almost mature seeds are probably more nutritious than the pods.

The dried, powdered seed of okra is used in soups, mixed with cheese, in salad dressings, ice creams, and candies. Oil expressed from the seed is useful as a cooking oil or for the production of margarine. The protein content of the seed makes it a valuable food crop.

The okra fruit is reported to be useful in the curing of ulcers and in the relief of hemorrhoids. Both uses are related to its mucilaginous character, which probably also accounts for its use as a clarifying agent in sugarcane processing.

The young leaves are sometimes used as a fresh vegetable. Indeed, they are not only appetizing but also have a higher protein content than the pods. The use of leaves is especially recommended for vigorous, much-branched varieties from which harvests of leaves and pods can be taken.

On an experimental scale, okra seeds have been ground into meal and used in baking as a substitute for part of the wheat flour and fat. The high protein and high oil contents make the meal especially nutritious. Okra seeds merit more study and development for such purposes.

Recipes

A few recipes taken from Beattie (5) are given below as illustrations of the ways fresh okra pods can be used:

OKRA SALAD

Boil the young okra pods whole for 10 minutes. When cold, dress with vinegar, salt, and pepper, or if preferred, use plain French dressing and serve cold. This is a delightful summer salad, the okra being cooling.

BOILED OKRA

1 quart young okra	pepper
1 pint water	1 tablespoon butter
1 teaspoon salt	1 tablespoon tarragon vinegar

Wash the okra and cut off the stem ends. Cook in boiling salted water until tender, or about 10 minutes. Drain and add seasoning. Serve hot or cold.

SCALLOPED OKRA AND TOMATOES

1 quart young okra	2 teaspoons salt
4 tablespoons butter or other fat	pepper
1 small onion, chopped	1 cup fine, dry breadcrumbs
1 quart fresh skinned chopped tomatoes or cooked tomatoes	

Select young okra, wash thoroughly, remove the stems, dry the okra, and cut in ½-inch slices. Melt 2 tablespoons of the fat in a frying pan, add the onion and okra, and cook until both are slightly browned, stirring frequently. Add the tomatoes, salt, and pepper, and simmer for about 10 minutes. Pour the mixture into a shallow greased baking dish, and cover with the bread crumbs mixed with the remaining melted fat. Bake in a moderately hot oven (350° F) for 10 minutes, or until the okra is tender and the crumbs are browned.

OKRA SOUP

2 pounds beef, without fat or bone	4 quarts cold water
2 cups okra, finely chopped	1 onion, sliced and chopped
1 pound butter	salt and pepper

Cut the beef into small pieces and season well with salt and pepper. Fry the beef in a soup kettle with the onion and butter until very brown. Add the cold water, and let simmer for 1½ hours. Add the okra, and let simmer gently for 3 to 4 hours longer.

Composition and Nutritional Value

Okra is usually considered a poor fresh vegetable. The nutrient content of cooked okra is given in table 5 (*1*). The amount of vitamin C is excellent. A 100-gram serving of okra will supply about half the recommended daily allowance (RDA) of vitamin C for an adult male. The contents of calcium, vitamin A, thiamine, and riboflavin are fair, each about 10 percent of the RDA. Phosphorus, iron, and niacin contents are significant but much less. Okra fruits are thus somewhat better than legumes with respect to vitamins A and C, but somewhat less than leafy vegetables; they are not as good as legumes with respect to the B vitamins, but better than most leaves. The caloric contribution of okra is low, reflecting the presence of little carbohydrate and little fat.

On a fresh-weight basis or on a dry-weight basis, okra leaves contain more protein than the pods (table 6). The nutritive values of the leaf protein is probably higher. Only the sulfur-containing amino acids are low (as in most plant tissue). The chemical score of 57 for the protein of okra leaves and a score of 37 for the

TABLE 5.—*Nutrient content of cooked okra*[1]

[Per 100 grams fresh weight]

Nutrient		Content	Percentage of RDA[2]
Water	pct	91.1	0
Calories	cal	29	1.07
Principal components:			
Carbohydrate	g	6.0	([3])
Fat	g	0.3	([3])
Protein	g	2.0	3.57
Minerals:			
Calcium	mg	92	11.50
Iron	mg	0.5	5.00
Phosphorus	mg	40	5.00
Potassium	mg	173	0
Sodium	mg	2	0
Vitamins:			
A	IU	500	10.00
Ascorbic acid	mg	20	44.44
Niacin	mg	1.0	5.56
Riboflavin	mg	0.18	11.25
Thiamine	mg	0.13	9.29

[1] Calculated from Adams (*1*).

[2] As a percentage of the amount required by an adult male (Food and Nutrition Board, National Academy of Science—National Research Council, 1974, Recommended Dietary Allowance, 8th edition.)

[3] See calories, above.

protein of the pods illustrate the better food value of the protein of the leaves (*9*).

Okra seeds contain a useful quantity of oil, from 14 to 19 percent, consisting of a good proportion of the essential fatty acid linoleic acid (*14*). The protein content of the seed, about 26 percent, makes the seed meal valuable as a feed. When separated from the hulls, the seed meal should be useful for human consumption.

In a study of okra seed as a source of oil and feed, Edwards (*7*) pointed out that the oil resembles a good grade of peanut oil. It is similar in composition to cotton oil. Okra oil should be useful as a salad oil, or after hydrogenation, as a margarine or shortening. After the oil has been extracted, the meal can be used as feed (43.56 percent protein and 31.50 percent carbohydrates). Machinery for processing cottonseed can be used to mill and crush okra seed (*12*). Because the hulls contain a small residue of protein, fat, and carbohydrates, they might be valuable for still other purposes.

TABLE 6.—*Water, protein, and amino-acid content of leaves and green fruits of okra*

[Per 100 grams fresh weight]

Nutrient		Content of leaves[1]	Content of green fruits[2]
Water	g	81.5	88.6
Protein:			
Fresh-weight basis	g	4.4	2.1
Dry-weight basis	pct	0.25	0.18
Amino acids:			
Cystine	pct of total amino acids	2.0	1.3
Isoleucine	do	4.7	3.0
Leucine	do	8.1	4.8
Lysine	do	5.8	4.2
Methionine	do	1.4	1.7
Phenylalamine	do	5.3	2.9
Threonine	do	4.9	2.9
Tryptophan	do	...	0.7
Tyrosine	do	3.5	7.9

[1] Chemical score: 57 (9).
[2] Chemical score: 37 (9).

PROSPECTS FOR THE FUTURE

Okra will continue to be utilized principally as a welcome and productive vegetable throughout the Tropics. Because of its adaptability, dependability, and resistance to hot, humid weather, okra will always be appreciated. It merits a place in home gardens and on subsistence farms, but it should never replace vegetables that are more nutritious but harder to produce.

The potential for okra seems to be as an oil and protein crop (*17*). Simple techniques have been developed to produce okra seed meal at the household level, and such meal can be substituted for a part of the wheat flour, and the oil used in baking (*21*). A technique to combine uses might be to grow okra as a vegetable crop during the rainy seasons, permitting the pods to mature during the dry season as a source of oil and meal. Some breeding work is desirable to incorporate resistances to diseases and insects in both garden and commercial varieties for the hot, humid Tropics.

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